No Sewers, No Problem

Using Onsite Submerged Aerobic Fixed Film Bioreactors to Treat Sanitary Wastewater

INTRODUCTION

Any company, land developer or individual who has attempted residential or commercial development in a rural suburban area is no stranger to the following scenario: "50 plus acres with good road frontage, high traffic count, public water and gas, but no sewer". Every thing about this hypothetical lot seems encouraging except "no sewer". The lack of public sewers is usually one of the primary factors that stops development in rural suburban areas. Typically, one of two possible scenarios exist:

1. Sewers are physically available, but they cannot be utilized because they become overwhelmed during storm events because of groundwater infiltration and/or surface water inflow (I/I).
2. The nearest tie in to a usable public sewer is too far from the property and/or too many easements are necessary to make the development economically feasible.

TRADITIONAL SOLUTIONS

The situation described above is not a new, unique problem. Traditionally, if a developer was faced with a sewerage problem, he or she could simply install one of many onsite sewage treatment systems available on the market. If the anticipated flow from the development was greater than 2,000 gallons per day, usually an activated sludge package plant was installed. In simple terms, these package plants are downsized versions of large publicly owned treatment works (POTWs) that directly discharge effluent offsite to a surface water (i.e. creek, river, lake, etc). Eventually, after hundreds of these treatment systems were installed across the United States, some of the drawback to the systems were discovered. For example, the package plants were often not maintained properly, which caused them to eventually malfunction and discharge effluent that was not fully treated. Additionally, direct discharge permits for new package plants (and any other sewage treatment systems) started becoming more and more difficult to obtain. As a result, the next best alternative to discharging effluent offsite is to discharge onsite. Smaller developments with anticipated flows less than 500 gallons per day (one residential house) have often utilized septic tanks for primary treatment discharging to a leachfield, which provides final treatment. This type of system requires very little maintenance, however, in order to achieve adequate final treatment, the site requires acceptable soil conditions, and a relatively flat large lot (at least 2.5 acres, depending on local codes). Additionally, many areas of the country do not allow these type of systems if the sewage source is commercial (i.e. restaurant). There are many alternatives to a traditional septic tank and leachfield, such as sand filters, small extended aeration units and constructed wetlands, however, each has its own set of problems with the largest being the requirement for routine maintenance.

MODERN SOLUTIONS

A recent concept that is gaining public and regulatory acceptance for residential and commercial sites is to extensively treat the sewage onsite to obtain a high water quality effluent, and instead of discharging the effluent offsite, discharge the effluent onsite. Discharging highly treated effluent onsite has many advantages over discharging septic tank effluent onsite or discharging offsite. For example, most soils more readily accept clean water than nutrient rich water, and discharging onsite does not require the extensive monitoring and permitting that offsite discharging requires. Sundry low maintenance techniques exist for discharge onsite including, but not limited to spray and drip irrigation systems, mound systems, evoptranspiration systems and leachfields. The question then becomes what is the least expensive, lowest maintenance, most reliable method for treating the sewage so that it can be discharged onsite. Traditional activated sludge package plants are capable of producing a relatively high quality effluent, but they often require high maintenance (i.e. sludge removal), and some plants produce offensive odors. Recirculating sand filters (RSFs) are also capable of producing a high quality effluent, however, RSFs can have problems treating higher strength waste (ie. from restaurants or dairies) and treatment efficiencies can be effected by decreases in temperature, especially in Northern climates. Submerged aerobic fixed film bioreactors[i] (SAFFBs) have proven very successful in treating normal and high strength sewage in any environment, while requiring very little maintenance and expense to operate.

HOW A SAFFB WORKS

A basic SAFFB is illustrated in Figure 1. A SAFFB consists of a tank filled with liquid (sewage influent) and packing media. A low flow of air is supplied to the tank and bubbles up through the liquid and packing media. Before sewage enters the SAFFB, the solids must first be removed using a septic tank. After the solids are remove, the liquid then enters the bioreactor and is mixed with the liquid in the tank, and randomly flows through the packing media. Inside the bioreactor, microorganisms break down nutrients in the liquid producing H_2O and carbon dioxide. After the liquid is treated it exits the tank and is ready for onsite discharge. Microorganisms that live in a SAFFB are identical to microorganisms found in any other aerobic sewage treatment system. In order to live and thrive, these microorganisms need food, oxygen and a place to live. The microorganisms use nutrients from the sewage for food, the oxygen is derived from the air flowing into the tank and the packing media provides a place to live (i.e. fixed film). Since the majority of the microorganisms live on the packing media and are not suspended in the liquid, a typical SAFFB produces very little sludge, which significantly decreases operating cost. One factor that significantly improves the efficiency of the microorganisms is temperature. Microbial activity, significantly decreases at temperatures less than 50 degrees Fahrenheit. If a SAFFB is placed inside an insulated building (especially in Northern climates), it can effectively retain its heat since the liquid coming from the ground is usually between 45-55 degrees Fahrenheit and the microbial activity inside the bioreactors is slightly exothermic.

CASE STUDY

An onsite treatment system utilizing two SAFFBs in series similar to the one described above was installed at a gas station/convenience store that also serves ice cream and food items. The facility is located in a rural suburban area just outside Cincinnati, Ohio. This site is located over a mile from the nearest public sewer, and the soils onsite are dense clay with a seasonably high water table (less than two feet from the surface). As illustrated in Table 1 sewage strength (measured in BOD) for this facility is higher than normal (1,100 ppm vs. 200-400 ppm normal). Figure 2 shows a generalized layout of the system. Sanitary wastewater from the facilities toilets and restroom sinks flows to a standard dual compartment septic tank. Sanitary wastewater from the mop sinks, food sinks and ice cream dip wells flows to a grease trap, prior to discharge into a standard dual compartment septic tank. Solids and grease free liquid then flows into a equalization/holding tank. The liquid is then pumped into the bottom of the first of two SAFFBs in series. The primary purpose of the first SAFFB is to reduce the BOD concentration. After mixing and residing in the first tank for an adequate residence period, the liquid then flows into the second SAFFB, which primarily reduces the ammonia and nitrates. Liquid from the second SAFFB is then disinfected to destroy any residual pathogens, and flows into a holding tank. From the holding tank the high quality treated water is either discharged to an onsite Wisconsin mound during cold weather months, or discharged to a spray irrigation system during warm weather months. Influent and effluent concentrations are tabulated in Table 1 and illustrated in Figure 3. As stated above, an important aspect of this system is that the SAFFBs are housed inside a temperature controlled building, and therefore operate efficiently year round. The operations cost for this system consists of occasionally pumping the septic tank and grease trap, and the electric cost for the pumps and air blowers. All electromechanical systems on this system have backups (i.e. secondary pumps. blowers, etc.) with alarms to indicate when the primary apparatus has failed. Since the treatment system is composed of very few moving parts, the system requires very little maintenance and oversight.

CONCLUSION

There are several factors than should be considered when choosing an onsite sewage treatment system, which include: treatment system capital cost vs. operational cost, site characteristics (i.e. soils, topography, etc.), strength and type of sewage influent, site climate, available greenspace and local and state regulations. Onsite sewage wastewater treatment is currently on the cusp of some significant changes. Developable commercial and residential areas that currently have access to sewers area becoming a rarity. While at the same time, development, especially in rural suburban areas seems to be outpacing the installation and/or upgrade of public sewage infrastructure. Resulting from low maintenance and high quality water effluent, utilizing a SAFFB for an onsite sewage treatment system helps a company, land developer, or individual obtain a balance between environmental consideration and economic feasibility.

BIOGRAPHICAL SKETCHES

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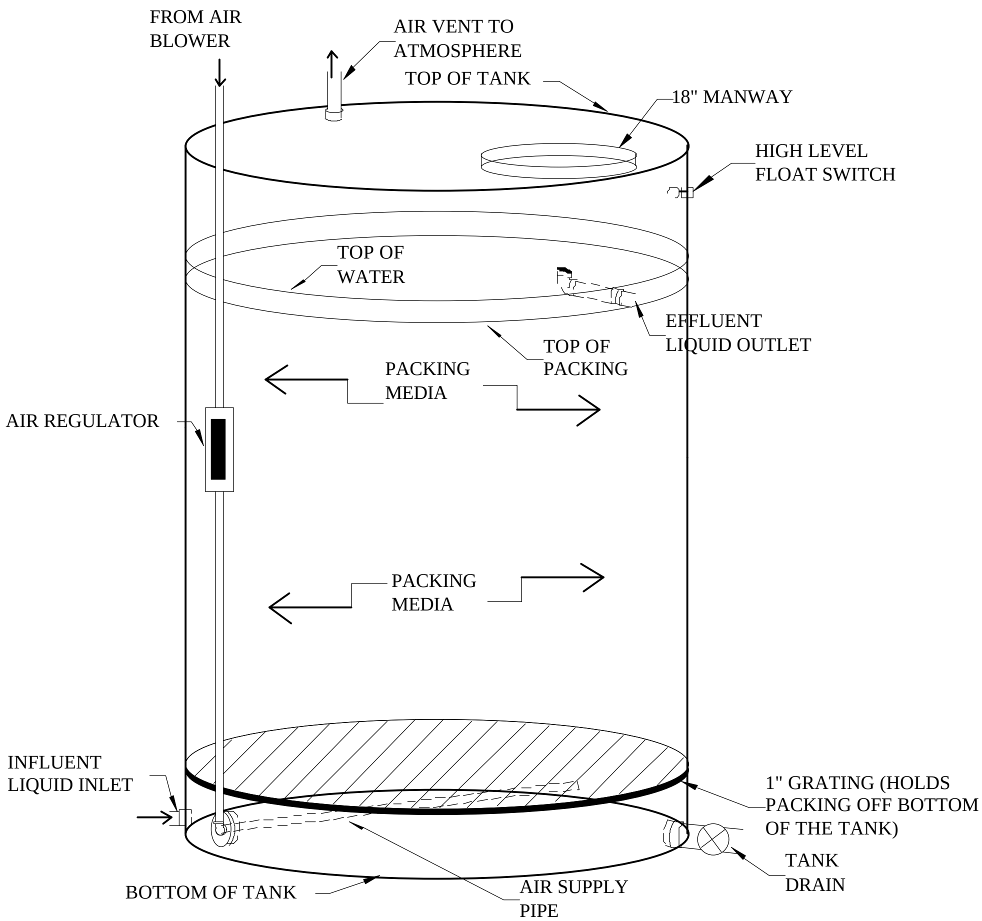

FIGURE 1 - General layout for a SAFFB

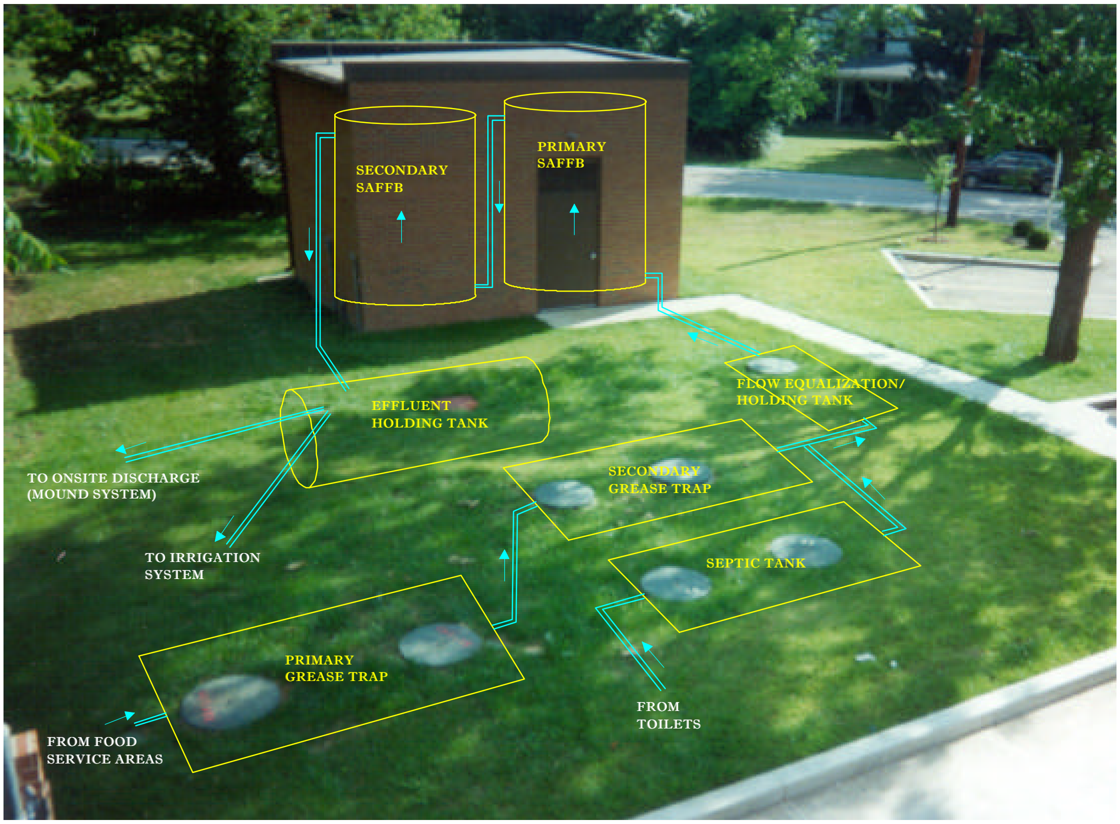

FIGURE 2 - Treatment system using two SAFFBs installed at a gas station/convenience store

Figure 3 -
Average Treatment System Results

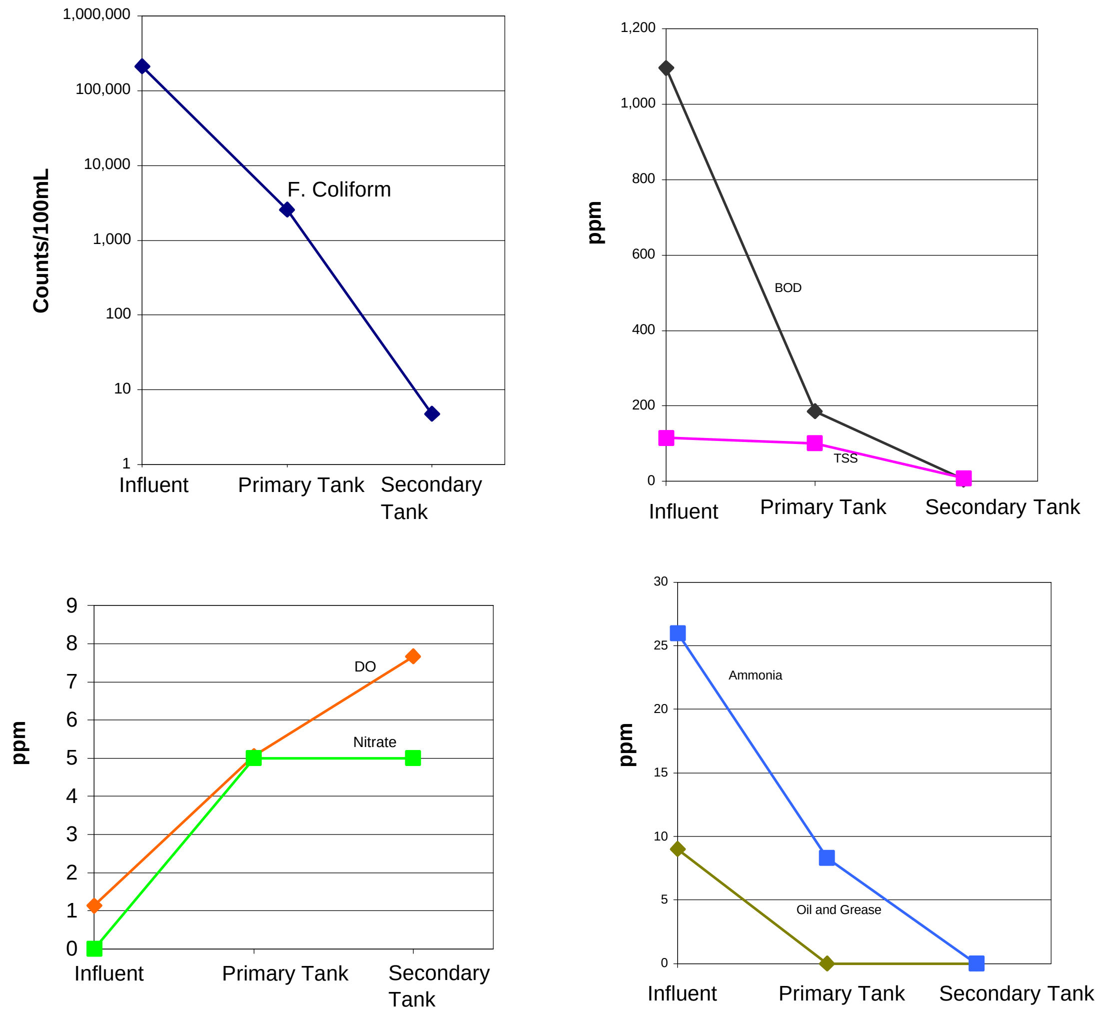

TABLE 1
AVERAGE INFLUENT AND EFFLUENT WATER QUALITY ANALYSIS
FOR QUARTERLY MONITORING EVENTS

DATE SAMPLED	NPDES Standard	Influent	Effluent Primary Tank	Effluent Secondary Tank
PARAMETER				
BOD (mg/L)	<10	1,096	186	5
DISSOLVED OXYGEN (mg/L)	>6	1.13	5.06	7.67
FECAL COLIFORM (counts/100 ml)	<100	209,630	2,570	5
AMMONIA (mg/L)	<1	>25	3	<1
NITRATE (mg/L)	<10	<0.1	5	5
TEMPERATURE (degrees F)	--	67	73	73
OIL & GREASE (mg/L)	--	9	<5	<5
TSS (mg/L)	<12	116	101	8

AMMONIA (mg/L) for chart	26	8.3	0
OIL & GREASE (mg/L)	9	0	0

[i] Utilizing a SAFFB in the manner describe above is protected under patent #6,444,126